UNSOLICITED RESEARCH PROPOSAL

for continuation of

DEVELOPMENT OF IMPROVED BLOWOUT PREVENTION PROCEDURES

TO BE USED IN DEEP WATER DRILLING OPERATIONS

Submitted to

THE UNITED STATES GEOLOGICAL SURVEY

DEPARTMENT OF THE INTERIOR

by

Adam T Bourgoyne Jr
A. T. Bourgoyne, Jr. Professor and Chairman
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ABSTRACT

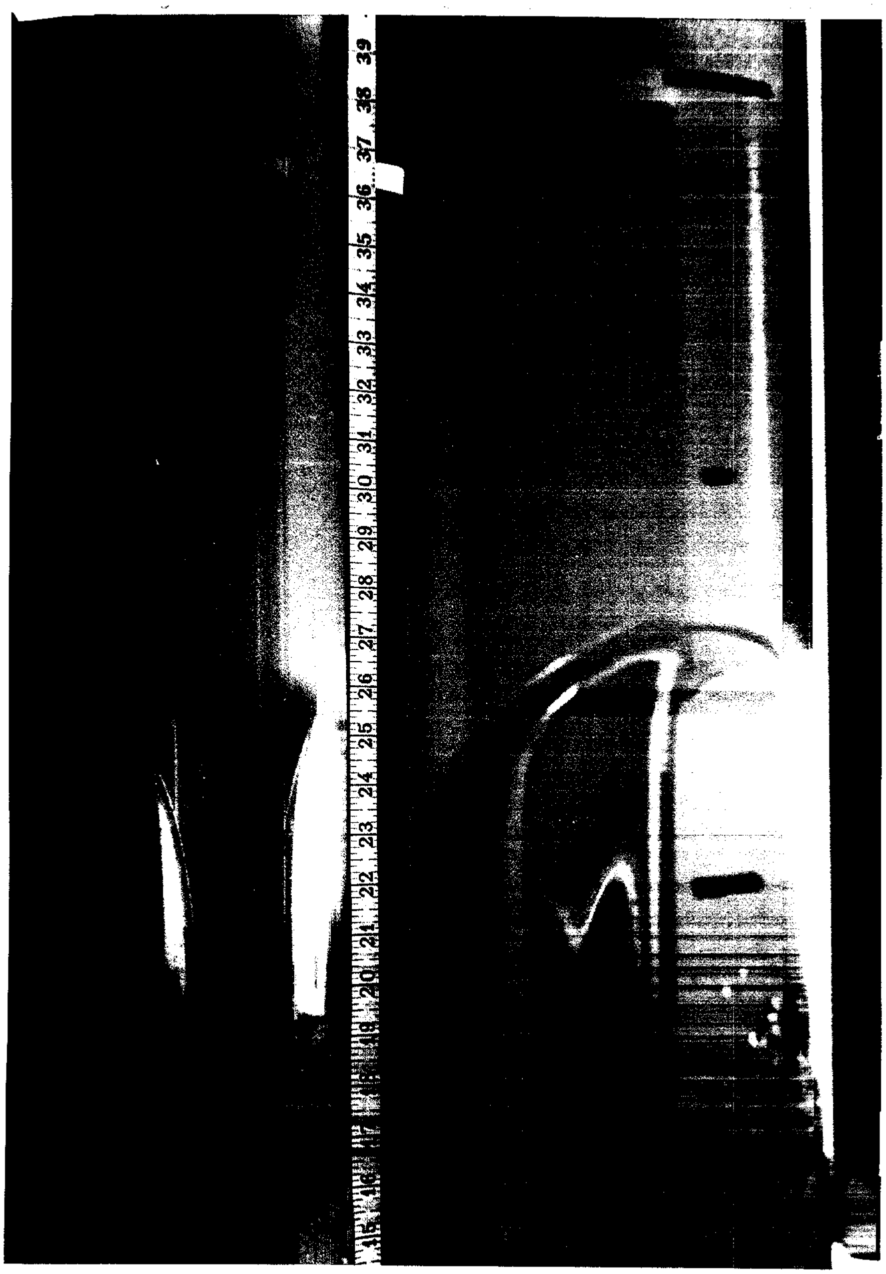
A number of new blowout control problems are associated with extending the search for hydrocarbons beyond the continental shelf to the deeper water depths of the continental slope using floating drilling vessels. In November, 1977, a proposal for research on the development of improved blowout prevention procedures to be used in deep water drilling operations was submitted to the USGS by the LSU Petroleum Engineering Department. The first phase of the proposed research has been initiated under USGS contract number 14-08-001-17225. This initial phase involves (1) the design of a well research facility for accurately modeling blowout control operations on a floating drilling vessel in deep water and (2) an experimental study of the flow characteristics of equipment used for well closure during an impending blowout. This initial work which is scheduled for completion by November 20, 1979, has progressed sufficiently to allow a second phase of the research project to be initiated. This research proposal concerns the experimental work planned for the second phase of this project.

TABLE OF CONTENTS

I. INTRODUCTION

As the search for petroleum reserves has moved into the offshore environment, the blowout control problems associated with exploratory and development drilling has continued to increase in complexity. In addition, the difficulties in confining an offshore oil spill makes the environmental consequences of a blowout more important. Modern well control equipment was largely developed for land based drilling operations. This equipment can also be applied with minor modifications to bottom supported exploratory drilling vessels such as jackups and development rigs operating on an offshore platform. More significant modifications in blowout prevention equipment were required for exploratory drilling done from floating drilling vessels capable of drilling in water depths beyond the range of bottom supported vessels. One major modification was the location of the blowout preventer valves on the sea floor rather than at the surface. Subsea flowlines are used to connect the blowout preventer stack to the adjustable choke at the surface.

A number of new blowout control problems are associated with extending the search for hydrocarbons beyond the continental shelf to the deeper water depths of the continental slope using floating drilling vessels. These problems become much more severe as the water depth increases, because of the increased length of the marine riser and subsea flowlines and the increased susceptibility of shallow formations to fracture. This research project is concerned with the development of improved blowout prevention procedures, which are better suited to deep water drilling operations.



II. RESEARCH OBJECTIVES

The primary objective of the proposed research is the development of improved well control procedures to be used in deep water, floating drilling operations. The specific areas to be investigated have now been changed slightly as a result of insight gained during the first phase of the project which is now in progress. Areas proposed for study at this time include improved shut-in procedures, procedures for handling upward gas migration during the shut-in period, pump start-up procedures, and pump-out procedures. A secondary objective is the development of a more accurate mathematical model of the well control process which will predict well behavior during various phases of well control operations for any assumed operating procedure.

Shut-In Procedures

There is still disagreement in the industry concerning the best procedure to follow when closing the blowout preventer and auxillary well control equipment during an impending blowout. Many operators prefer a rapid shut-in procedure, with the idea of minimizing the influx of formation fluids as much as possible. Others favor a soft shut-in procedure, with the idea of minimizing any shock pressure loadings associated with the rapid deceleration of the fluid being ejected from the well. This problem has been studied mathematically by several companies, but the results are always clouded by the "simplifying assumptions" made in the mathematical analysis. Experimental research using actual blowout prevention equipment is needed to resolve this issue. Also, the wide variety of equipment configurations and shut-in sequences currently used on floating drilling vessels should be studied. The shut-in problem will become much more critical as drilling operations move into deeper water depths.

Upward Gas Migration During Shut-In Period

After a kick is detected and the well is shut-in, the well pressures initially increase in response to formation *afterflow*. Afterflow refers to transient flow from the formation into the wellbore at the hole bottom just after the well is closed at the surface. Surface pressures rise more rapidly at first because of a larger pressure drawdown on the formation which results in a higher formation flow rate. As the fluids trapped in the well are compressed and the well pressures rise, this flow gradually decreases and finally stops.

In some cases, problems may develop which prevent the initiation of kick circulation for long periods of time. In other cases, problems may develop during kick circulation which require that the well be again shut-in with kick fluids still in the well. If the kick fluids are gas and the well remains shut-in for a long period of time, the gaseous zone trapped in the well may tend to migrate a significant distance towards the surface. This movement occurs because the gas zone has a much lower density than the drilling fluid. Gas rising in a shut-in well will cause a gradual increase in pressure at all points in the well. This pressure increase occurs because if the well remains closed, the gas cannot expand. The pressure of a gas held at constant volume and temperature must also remain constant. Unacceptably large increases in well pressures can result which will probably result in formation fracture or equipment failure. In order to avoid this unacceptably large increase in well pressure, the gas should be allowed to expand under controlled conditions to keep the bottom hole pressure constant at a value slightly above formation pressure.

Changes in bottom hole pressure are most easily ascertained from observed changes in surface drill pipe pressure. However, additional complications sometimes exist which cause a meaningful drill pipe pressure to be unavailable. Example situations for which this is true include (1) wells in which the drill string is partially or completely out of the hole and (2) wells which develop mechanical problems in the drill string such as a plugged bit or a leak (washout) at a pipe joint. An alternative method of safely handling upward gas migration when a meaningful drill pipe pressure is not available has been recently proposed in the literature. Several variations of this method, called the volumetric method, is now being incorporated into the well control manuals of many operators.

The volumetric methods of handling upward gas migration were developed largely from theoretical considerations of the annular pressure behavior under the following simplifying assumptions:

1. The gas enters the well as a slug and rises to the surface as a unit.
2. The gas density is negligible and does not contribute to the bottom hole pressure.
3. Hydrostatic pressure relationships apply throughout the region of the wellbore where gas movement is occurring.

Preliminary experiments conducted at LSU indicate that the first assumption is not valid. An experimental study in a full scale well is needed to determine under what conditions the volumetric method can be safely applied.

Start-Up Procedures

The present-day well control method used to initiate the circulation of formation fluids from the wellbore is to start pumping while simultaneously opening the choke so that the casing pressure is maintained constant at, or slightly above, its previous shut-in value. Because of the high frictional pressure drop in the long underwater flowlines associated with floating drilling operations, this procedure can produce an excessive annular back-pressure. This in turn could lead to formation fracture and a subsequent underground blowout. In addition, the subsea flowlines are sometimes filled with water to prevent plugging of the flowlines when they are not in use. This complicates the annular pressure behavior during start-up because of the density difference between the water initially in the flowline and the drilling fluid which will ultimately displace this water.

Pump-Out Procedures

When a gas influx (kick) is circulated from a well, an operational problem results when the gas bubble reaches the subsea preventer stack located on the ocean floor. There follows a very rapid elongation of the bubble as it exits the large casing and proceeds upward through the small diameter choke line which parallels the larger marine riser pipe. There is the question whether an operator would have adequate time to respond properly to the rapidly changing pressure conditions associated with this phenomenon. This problem should be studied experimentally from the standpoint of improving pump-out procedures to be used with existing equipment and the standpoint of improving equipment design.

Improved Mathematical Model

Many modern blowout control strategies are based solely upon the response of mathematical models of the drilling well system during various phases of blowout control operations. For example, a modified Wait and Weight Method of well control, known as the Simplex Method, is based upon calculations which suggest that casing pressure should not change during the time required to pump kill mud to the bottom of the well. This technique thus requires manipulating the adjustable choke to maintain the casing pressure constant while kill mud is circulated to the bit. It is recommended by some engineers as a way to eliminate the calculation of the normal schedule of drill pipe pressure changes associated with the more conventional Wait and Weight Method. These mathematical models are also being employed at present by some authors to develop new procedures for floating drilling operations.

Preliminary research at LSU has already shown that the mathematical models used at present in blowout control simulations do not always predict actual well behavior. Two assumptions found to be at fault are (1) that gas influx enters the well bore as a continuous slug and remains in this configuration during subsequent control operations and (2) that the gas bubble does not migrate upward through the column of drilling mud but moves instead at the same velocity as the circulating mud. Additional research is needed to improve our understanding of true well behavior.

III. RESEARCH PLAN

As currently envisioned, the proposed overall research project can be divided into eight tasks. Each of these tasks can be subdivided into two or more subtasks. These tasks and subtasks are:

1. Design of well for accurately modeling blowout control operations on a floating drilling vessel in deep water.
   a. Well scaling and design.
   b. Preparation of bids and specifications.
2. Construction of well for accurately modeling blowout control operations on a floating drilling vessel in deep water.
   a. Procurement of well equipment.
   b. Well drilling and completion.
3. Documentation of blowout control equipment configuration and procedures used on all floating drilling vessels capable of drilling in deep water.
   a. Equipment configuration.
   b. Shut-in procedures.
   c. Start-up procedures.
   d. Pump-out procedures.
4. Experimental study of shut-in procedures for blowout control on floating drilling vessels in deep water.
   a. Experimental determination of frictional area coefficient profile of modern adjustable chokes and HCR valves used in Blowout Control operations.

b. Experimental Determination of Frictional Area Coefficient Profile of Modern Annular Blowout Preventers During Closure.

c. Development of Mathematical Model of Pressure Surges Occurring During Well Closure.

d. Experimental Evaluation of Pressure Surge Model.

e. Determination of Optimal Shut-In Procedures for Various Well Conditions.

5. Experimental Study of Procedures for Handling Upward Gas Migration during the Shut-in Period.

   a. Evaluation of conventional approach requiring use of surface drill pipe pressure.

   b. Evaluation of volumetric methods.

   c. Laboratory investigation of gas bubble fragmentation while rising in a static annulus.

   d. Development of mathematical model of well behavior during shut-in period following a gas kick.

   e. Determination of optimal method of handling upward gas migration during shut-in period.

6. Experimental Study of Start-up Procedures for Blowout Control on Floating Drilling Vessels in Deep Water.

   a. Evaluation of Present Day Start-up Procedures which use existing equipment.

   b. Evaluation of Possible Future Start-up Procedures which would require development of new equipment.

   c. Experimental Determination of Improved Start-up Procedures.

7. Experimental Study of Pump-out Procedures for Blowout Control Operations on a Floating Drilling Vessel in Deep Water.
   a. Evaluation of Present Day Pump-out Procedures which use existing equipment.
   b. Evaluation of Present Day Pump-out Procedures which would require development of New Equipment.
   c. Experimental Determination of Improved Pump-out Procedures.
8. Determination of Well Behavior During the Control of Gas Kicks on Floating Drilling Vessels.
   a. Experimental Determination of Annular Pressure Behavior For Various Well Conditions.
   b. Development and Verification of Accurate Mathematical Model of Well Behavior during Kick Pump-out.

The first phase of the project which was funded in August of 1978 involved the completion of Task 1 and Subtask 4a and Subtask 4b. This initial work which is scheduled for completion by November 20, 1979, has progressed sufficiently to allow a second phase of the research project to be initiated. It is proposed that the second phase of the project involve the completion of Task 4 and Task 5. These tasks can be accomplished with relatively minor modifications of the present facility prior to the completion of the new well configuration designed as part of Task 1. An updated time schedule for performing the various tasks is presented as Figure 1.

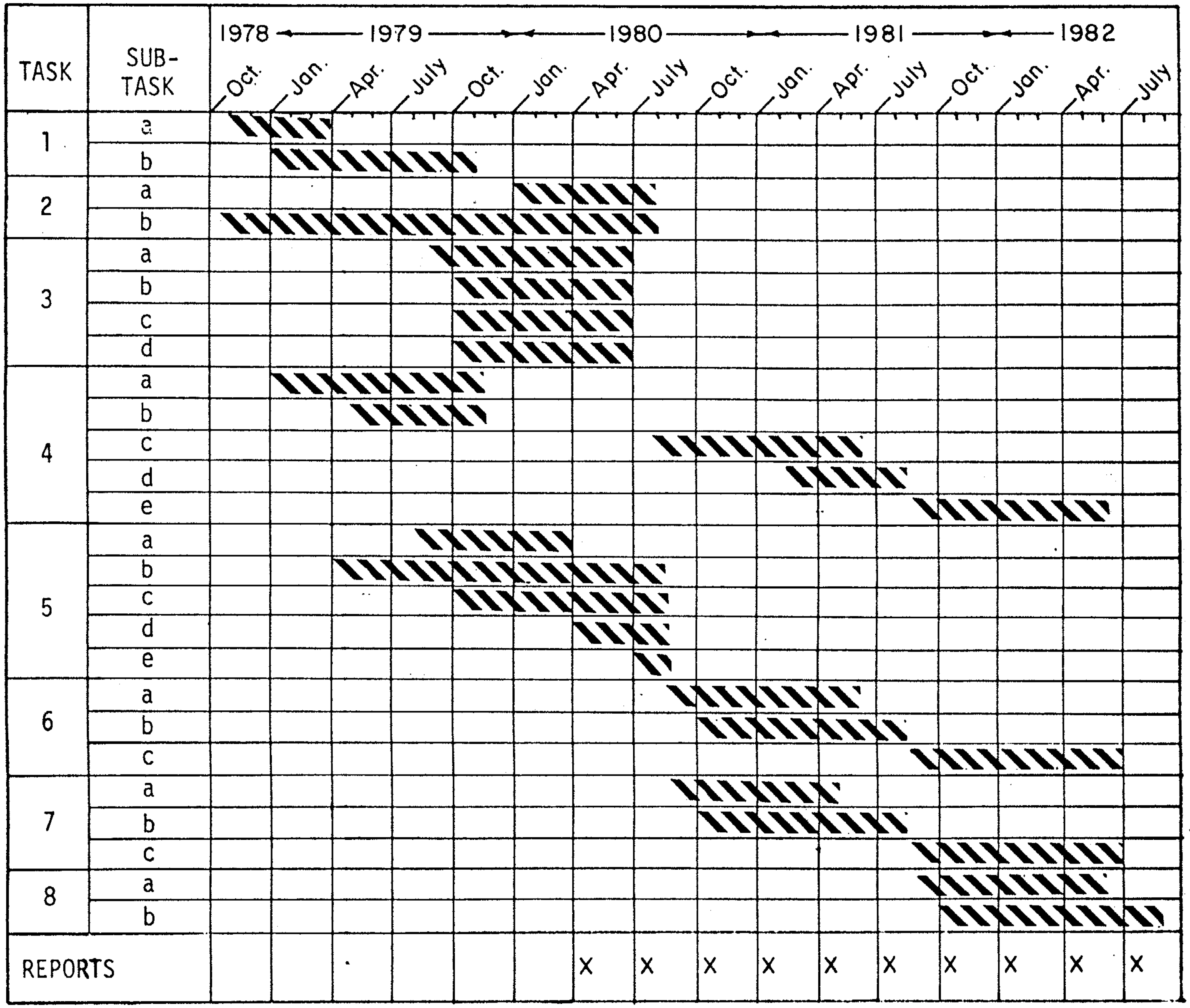


FIGURE I. ESTIMATED TIME SCHEDULE FOR PROJECT

IV. PROGRESS SUMMARY

Tasks 1a and 1b have been essentially completed. The design of the well was aided by computer simulations of (1) a large number of well control operations for a large variety of deep water drilling operations, and (2) a variety of model well geometries. A model well configuration representative of field cases of practical interest was then selected. A current "state of the art" well control computer model was used in these simulations. This computer model assumes (1) that any formation gas which enters the well remains as a continuous slug which occupies the entire cross sectional area of the annulus during all of the well control operation and (2) that the gas does not slip with respect to the drilling fluid during the well control operations. While these assumptions are not entirely valid, the results obtained are felt to be sufficiently valid to allow a representative model well geometry to be selected. A stated research objective of the model well is to allow an improved mathematical model of the well control process for floating drilling operations to be developed.

A 9000 ft well cased with 7-5/8 in. steel casing has been acquired on the LSU campus which is suitable for use in the well facility needed to model the deep water well control process. The well, which has a value in excess of $400,000 was given to the Petroleum Engineering Department at LSU by GoldKing Production Company after completion of a deep test on university land which did not yield commercial hydrocarbon production. The Petroleum Engineering Department has been allocated a 1.4 acre tract of land containing the well by the university to support the development of the improved research facility. In return, the Petroleum Engineering Department and the Blowout Prevention Training Center have provided approximately $20,000 of the funds needed for relocating the Dairy Science fences and structures on this property. No USGS funds were needed for the relocation of the Dairy Science fences and structures. The acquisition of this well from GoldKing Production Company will eliminate approximately 60 percent of the estimated well construction cost for Task 2 quoted on page 38 of the original proposal.

The design of the surface support equipment needed for the research well has also been essentially completed. Considerable input was obtained from personnel with several major oil companies during the design phase of the project. A site visit was made to an Exxon blowout control training facility in Texas, which at present, is the facility most similar to the planned research well. Site development plans, including needed excavation and foundations, drainage, and utilities was prepared by a consulting firm which the university uses for this purpose. Specifications and cost estimates on the needed surface equipment have been obtained.

The experimental work need for Task 4a has begun at the existing training well facility. Preliminary results are very promising and some minor flow loop modifications have now been completed which will allow data to be taken over a wider range of flow rates and choke pressures. Experimental work needed to complete Task 4b will be started within the next month.

The experimental study of the volumetric method of handling upward gas migration has also been started. A portion of the needed equipment modifications has been completed and considerable data on one variation of the volumetric method has been obtained. The results have significantly increased our understanding of the actual well behavior during upward gas migration and a technical publication presenting our results is being prepared.

No significant problems have been encountered to date. The project is only slightly behind schedule and it is anticipated that the initial tasks funded can be completed without exceeding the initial budget request by more than about $10,000.

The scheduled completion of the new well facility for modeling blowout control operations on a floating drilling vessel has been pushed back about a year to allow time to present proposals of the planned facility to representatives of many oil companies and drilling contractors with the hope of funding as much of the construction costs as possible through industry grants. The planned research facility site has been moved to take advantage of a new well provided by GoldKing Production Company. The new well is near the existing training well facility.

V. FUNDING REQUEST FOR PHASE II

It is recommended that the second phase of this project, consisting of Task 3 and Task 5, be scheduled for the period between August 1, 1979 and September 1, 1980. This work could be accomplished at a total cost to the USGS of $96,311. The proposed budget is shown in Table 1.

Task 3, the documentation of blowout control equipment configurations and procedures used on deep water drilling vessels, would take approximately eleven months to complete. This work would be accomplished by one graduate assistant and one part-time research associate under the supervision of Dr. A. T. Bourgoyne. An attempt would be made to include all floating drilling vessels capable of drilling in excess of 1000 feet of water. The Drillships presently having this capability are listed in Table 2 and the Semi-Submersibles having this capability are listed in Table 3. The rig owner of each of the 60 drilling vessels capable of drilling in deep water would be contacted and schematics showing the present blowout control equipment configuration would be prepared. The schematics would include the placement of blowout preventers, flowlines, valves, chokes, separators, diverters, etc. for various casing programs. In addition, the shut-in procedures, start-up procedures, and pump-out procedures followed with the given equipment would be documented to the extent possible. It is anticipated that a significant amount of travel will be required to accomplish this task.

Task 5, the experimental study of procedures for handling upward gas migration during the shut-in period, would take approximately thirteen months to complete. This work would be accomplished by two graduate assistants and one part time research associate under the supervision of Dr. A. T. Bourgoyne. A portion of the experimental work would be conducted using the existing full scale training well facility under simulated gas kick conditions. However, to gain additional insight into the mechanisms responsible for the pressure behavior observed in the full scale well, additional experiments will be conducted in a model well bore installed in a three story vertical shaft housed within the petroleum engineering department. Schematics of the vertical shaft research facility are shown in Appendix B. A model wellbore valued at approximately $10,000 will be available for this work.

TABLE 1

PROPOSED PHASE II BUDGET

TASK 3 and TASK 5

August 1, 1979 - September 1, 1980

1.	Direct Costs	
	a. Personnel	
	(1) Principal Investigator A. T. Bourgoyne, Jr. 5.25 man-months (1/4 time during academic year plus 3 months during summers)	19,192
	(2) Graduate Assistants 19.5 man-months (three students; 1/2 time)	13,748
	(3) Research Associate Samuel W. Crouch 13 man-months	17,100
	(4) Typist/Clerk 6.5 man-months	3,940
	Sub.	53,980
	b. Employee Benefits (15.6% of 1a)	8,421
	c. Drilling Fluid Chemicals and Nitrogen Gas	1,500
	d. Office Supplies and Report Reproduction Costs	2,500
	e. Travel	4,000
2.	Indirect Costs (48% of 1a)	25,910
	Total	96,311

TABLE 2 - DRILLSHIPS CAPABLE OF DRILLING IN WATER DEPTHS IN EXCESS OF 1000 FEET

	Rig Owner	Rig Name	Maximum Depth
1	Amoshore Drilling Co.	Discover 511	2,000'
2	Atwood/Drillships Ltd.	Regionl Endeavour	1,506'
3	Dome Petroleum (Canmar Drilling)	Canmar Explorer III	1,500'
4	C. G. Doris	Astragale	1,800'
5	Global Marine Inc.	Glomar Atlantic	2,000'
6	Global Marine Inc.	Glomar Challanger	20,000'
7	Global Marine Inc.	Glomar Coral Sea	1,500'
8	Global Marine Inc.	Glomar Java Sea	1,500'
9	Global Marine Inc.	Glomar Pacific	2,000'
10	Helmer Staubo & Co.	Pelerin	3,300'
11	IHC Holland		3,300'
12	Interocean Drilling	Interocean Discoverer	1,500'
13	Marine Drilling & Coring Co.	Candrill I	5,000'
14	Mission Drilling & Exploration Corp.	Mission Viking	1,500'
15	Neddrill (Nederland) B. V.	Neddrill II	6,000'
16	ODECO/Ben Line Offshore	Ben Ocean Lancer	3,000'
17	The Offshore Co.	Discoverer II	1,500'
18	The Offshore Co.	Discoverer 534	3,000'
19	The Offshore Co.	Discoverer Seven Seas	4,500'
20	Offshore Europe N. V. (Foramer)	Petrel	3,000'
21	Overseas Drilling Ltd.	Sedco/BP 471	4,500'
22	Pacnorse Drilling Corp.	Pacnorse I	3,000'
23	Saipem	Saipem Due	2,000'
24	Sedco Inc.	Sedco 445	3,500'
25	Sedco Inc.	Sedco 472	4,500'
26	Western Offshore Drilling & Expl. Co.	Western Offshore IV	1,500'
27	Western Offshore Drilling & Expl. Co.	Western Offshore V	1,500'

TABLE 3 - SEMI-SUBMERSIVES CAPABLE OF DRILLING
IN WATER DEPTHS IN EXCESS OF 1000 FEET

	Rig Owner	Rig Name	Maximum Depth
1	Atlantic Drilling Co.	No. 786	1,100'
2	Celtic Drilling Co.	Sea Conquest	1,200'
3	Deep Sea Drilling Co. A/S	Deepsea Saga	1,500'
4	Diamond M Co.	Diamond M General	1,100'
5	Dixilyn-Field Drilling Co.	Venture One (Pentagone)	1,200'
6	Dixilyn-Field Drilling Co.	Venture Two (Pentagone)	1,200'
7	Dolphin International	Bideford Dolphin	1,500'
8	Fearnley Drilling & Expl. A/S	Fernstate	3,000'
9	Japan Drilling Co. Ltd.	Hakuryu V	1,650'
10	Keydril Co.	Aleutian Key	2,000'
11	Marine Drilling S. A.	Sedco 707	1,500'
12	Marine Drilling S. A.	Sedco 709	6,000'
13	K/S Morland Offshore A/S	Gulnare (pentagone 91)	1,200'
14	A/S Norsedrill & Co.	Drill Master	1,200'
15	ODECO	Ocean Queen	1,200'
16	Japan/ODECO	Ocean Bounty	1,200'
17	ODECO/Fearnley & Eger	Ocean Ranger	1,500'
18	Santa Fe International	Blue Water No. 4	1,500'
19	Sante Fe International	Southern Cross	1,500'
20	Sedco Inc.	Sedco 135c	1,500'
21	Sedco Inc.	Sedco 703	2,000'
22	Sedco Inc.	Sedco 704	1,500'
23	Stavanger Drilling A/S & Co.	Henrik Ibsen	1,200'
24	Stavanger Drilling A/S & Co.	Alexander L. Kielland	1,200'
25	Western Oceanic/Exxon	Alaskan Star	1,500'
26	Western Oceanic	Western Pacesetter II	1,200'
27	Western Oceanic	Western Pacesetter III	1,200'
28	Wilh. Wilhelmsen	Treasure Seeker	1,250'
29	Zapata Corp.	Zapata Concord	2,000'
30	Zapata Corp.	Zapata Lexington	2,000'
31	Zapata Corp.	Zapata Saratoga	2,000'
32	Zapata Corp.	Zapata Ugland	2,000'
33	Zapata Corp.	Zapata Yorktown	2,000'

VI. PRINCIPAL INVESTIGATOR

Professor A. T. Bourgoyne, Jr. will serve as principal investigator for the proposed second phase of this research project. Professor Bourgoyne has maintained an active interest in blowout control for the past six years. This past year, he authored four papers in the area of well control and blowout prevention and was responsible for the "complications and special well control techniques" section of the USGS approved blowout control training program at LSU. Also during the past year he served as a consultant to Otis Engineering Corporation on a well control project and as a consultant to Placid Oil Company in planning the well killing operation used to bring a blowout, which occurred in the Gulf of Mexico, under control. This next year, he will assume responsibility for testing and certification in the LSU blowout control training program. Dr. Bourgoyne also is now preparing a technical paper on some of the results obtained during the first phase of the USGS sponsored research program.

Dr. Bourgoyne's professional resume is included in Appendix A.

APPENDIX A

PROFESSIONAL RESUME OF PRINCIPAL INVESTIGATOR

PROFESSIONAL RESUME

Adam T. (Ted) Bourgoyne, Jr., Chairman
Petroleum Engineering Department
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Personal Information

Born July 1, 1944, Baton Rouge, LA
Married Kathryn Daspit of Baton Rouge, LA, Jan. 22, 1966
Children: Four Boys and Two Girls
Home Phone: (504) 766-7507
Home Address: 6006 Boone Drive, Baton Rouge, LA 70808

Education

B.S. in Petroleum Engineering, Cum Laude, 1966,
Louisiana State University

M.S. in Petroleum Engineering, 1967,
Louisiana State University

Ph.D. in Petroleum Engineering, 1969,
University of Texas at Austin

Experience - Summer

	Company	Job Description	Date
1.	Mobil Oil Co.	Drilling & Production Roustabout	Summer 1963 1964, 1965
2.	Texaco, Inc.	Asst. Drilling Engineer	Summer 1966
3.	Chevron Research	Reservoir Simulation Group	Summer 1967
4.	Continental Oil (Research)	Surfactant Research	Summer 1968
5.	Baroid Division of N.L. Industries Inc.	Well Monitoring and Pressure Detection	Summer 1972

Experience - Permanent

1. Continental Oil Company - Production Engineering Services Group, Houston, Texas, 1969-1971. Worked primarily on computer applications in drilling and production. Work included drilling data acquisition, abnormal pressure detection, optimization of drilling hydraulics, optimization of bit weight and rotary speed, design of flowline networks involving simultaneous flow of gas and liquids, design of submersible electric pump installations.

Experience - Permanent - Cont'd

2. Louisiana State University - Petroleum Engineering Department, 1971 - Present. Primary duties involve teaching undergraduate and graduate courses in Petroleum Engineering and the supervision of graduate student research. At present, serving as Chairman of the Petroleum Engineering Department.

Professional Societies and Activities

1. Registered Professional Engineer(Petroleum) in Louisiana - No. 15776.
2. Tau Beta Pi
3. Pi Epsilon Tau
4. AIME-SPE(Presently charged with writing SPE sponsored textbook on drilling).
5. API(Presently serving on national committee concerning the determination of formation pore pressures and fracture gradients).

Activities at LSU

Courses Taught

Introduction to Petroleum Engineering, Reservoir Fluid Flow, Phase Behavior of Hydrocarbon Systems, Economic Aspects of Petroleum Production, Drilling Engineering, Drilling Fluids Laboratory, Advanced Drilling Engineering, Advanced Reservoir Engineering, Advanced Drilling Fluid Rheology, and Risk Analysis in the Petroleum Industry.

Short Courses

Have participated extensively as instructor in Blowout Control Training Center. Have also participated in Well Completion Short Courses.

Committees

1. Engineering Self Study Committee, 1969-70
2. Engineering Policy Committee, 1976-77
3. Engineering Student Affairs Committee, 1970-1977 (Chairman 1976-77)
4. Department Graduate Program Committee
5. SPE Student Paper Contest Advisor

Theses Directed

1. Mannarino, Remo: "The Effects of Sealing and Non-Sealing Faults on Pressure Build-up and Pressure Drawdown Analysis", August, 1971.
2. Lavaquial, Fernando P.: "Water Influx Into Petroleum Reservoirs From Adjacent Shales", August, 1971.

Theses Directed - Cont'd

3. Rader, David W.: "Movement of Gas Slugs Through Newtonian and Non-Newtonian Liquids in Vertical Annuli, May, 1973.
4. Simmons, Richard D.: "A Comparison of Horizontal Multiphase Flow Pressure Loss Correlations" May, 1973.
5. McKenzie, Michael F.: "Factors Affecting Surface Casing Pressure During Well Control Operations", August, 1974.
6. Ward, Robert H.: "Movement of Gas Slugs Through Static Liquids in Large Diameter Annuli", August,1974.
7. Koederitz, W. L.: "The Mechanics of Large Bubbles Rising in an Annulus" May, 1976.
8. Mathews, Gerald L.: "A Microscopic Investigation of the Use of Preferentially Oil Soluble Surface Active Agents to Enhance Oil Recovery", May, 1977.
9. Paulinus, Ofoh Ebere: "The effect of Flood Rate on Displacement Efficiency When Using Oil Soluble Surface Active Agents to Enhance Oil Recovery", May 1978.
10. Sample, Kenneth John: "Development of Improved Procedures for Determining the Carrying Capacity of Drilling Fluids", August 1978.
11. Bizanti, Mohamed: "New Bit Designs for Reducing Bottom Hole Pressure While Drilling", December 1978.

Technical Publications

1. "A Critical Examination of Rotary Drilling Hydraulics", M.S. Thesis, Louisiana State University, 1967.
2. "Graphs Simplify Drilling Hydraulics", World Oil (Jan., 1969) 57.
3. "Numerical Simulation of Drillstem Tests as an Interpretation Technique", J. P. Brill, A. T. Bourgoyne, and T. N. Dixon, Journal of Petroleum Technology (Nov., 1969) 1413.
4. "The Effect of Interfacial Films on the Displacement of Oil by Water in Porous Media", Ph.D. Dissertation, University of Texas, 1970.
5. "Computer Graphics Improve Drilling Hydraulics", A. T. Bourgoyne and R. E. McKee, Petroleum Engineer (Sept., 1970) 59.
6. "Porosity and Pore Pressure Logs", A. T. Bourgoyne, J. A. Rizer, and G. M. Myers, The Drilling Contractor (May-June, 1971) 36.
7. "A Graphic Approach to Overpressure Detection While Drilling", Petroleum Engineer(Sept., 1971) 76.
8. "The Effect of Interfacial Films on the Displacement Efficiency of a Waterflood", Trans. AIME (1971).
9. "Water Influx into Petroleum Reservoirs from Adjacent Shales", Proceedings of Third Sympsoim on Abnormal Pressure(May, 1972).
10. "A Multiple Regression Approach to Optimal Drilling and Abnormal Pressure Detection", A. T. Bourgoyne, and F.S. Young, Proceedings of Sixth Conference on Drilling and Rock Mechanics(Jan. 1973) also Trans. AIME, 1974.

Technical Publications - Cont'd

11. "The Use of Drillability Logs for Formation Evaluation and Abnormal Pressure Detection", A. T. Bourgoyne and F.S. Young, "Proceedings of SPWLA Fourteenth Annual Logging Symposium" (May, 1973).

12. "Factors Affecting Bubble Rise Velocity of Gas Kicks", D. W. Rader and A. T. Bourgoyne, Jr., Journal of Petroleum Technology, (May 1975).

13. "Graphic Approach to Kick Severity Calculations", A. T. Bourgoyne, Jr., Petroleum Engineer, (Sept. 1976).

14. "An Experimental Evaluation of Correlations Used for Predicting Cutting Slip Velocity", K. J. Sample and A. T. Bourgoyne, SPE 6645, Presented at 52nd Annual Fall Meeting of SPE, Denver, Colorado(Oct. 1977). Also accepted for publication in Journal of Petroleum Technology.

15. "Well Control Procedures For Deepwater Drilling-Part 1," A. T. Bourgoyne, W. R. Holden, B. R. Hise, and R. S. Sullins, Ocean Resources Engineering, (April, 1978)20.

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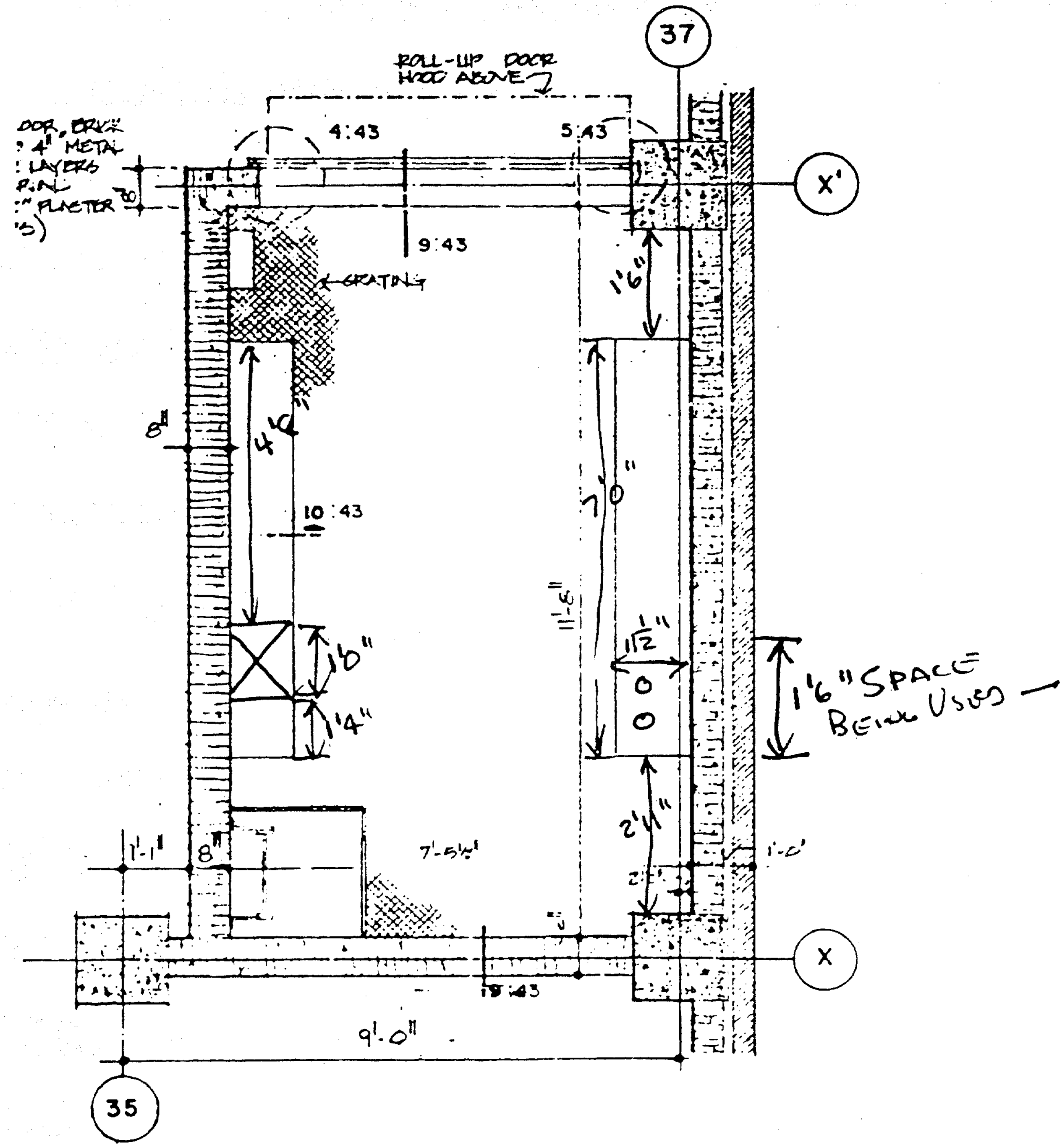
APPENDIX B

PLANS FOR VERTICAL SHAFT



VERTICAL SHAFT PLAN

PROGRESS REPORT

April 23, 1978 - July 23, 1979

Development of Improved Blowout Prevention Procedures for Deep Water Drilling Operations

Contract No. 14-08-0001-17225
Effective Date: August 23, 1978
Expiration Date: November 20, 1979
Funded Amount - $90,785

Sponsored by

The United States Geological Survey

The Department of Interior

Reston, Virginia

Principal Investigators:

William R. Holden, Professor
Petroleum Engineering Department

A.T. Bourgoyne, Professor and Chairman
Petroleum Engineering Department

Bill R. Hise, Professor
Petroleum Engineering Department

July 24, 1979

RESEARCH OBJECTIVES

A number of new blowout control problems are associated with moving into deep water drilling operations with floating drilling vessels. These problems become much more severe as the water depth increases, because of the increased length of the marine riser and subsea flowlines and the increased susceptibility of shallow formations to fracture. The primary objectives of the proposed research are the development of improved well control procedures to be used in deep water, floating drilling operations.

The overall research project being undertaken is the development of improved shut-in procedures, pump start-up procedures, and procedures for more safely circulating formation gas to the surface. In addition, an improved mathematical model of the well control process is being developed which will allow an accurate prediction of well behavior for various assumed operating procedures. An existing $750,000.00 blowout control training well facility is being modified to accomplish these objectives.

The overall research plan was divided into eight tasks which would take approximately four years for completion. The initial project funding received under the present contract was $90,785 for a fourteen month period to perform Tasks 1a, 1b, 4a, and 4b. These tasks include:

Task	Description
1	Design of a well for accurately modeling blowout control operations on a floating drilling vessel in deep water.

Task	Description
a.	Well scaling and design.
b.	Preparation of bids and specifications.
4	Experimental study of shut-in procedures for blowout control on floating drilling vessels in deep water.
a.	Experimental determination of frictional area coefficient profile of modern adjustable chokes and HCR valves used in blowout control operations.
b.	Experimental determination of frictional area coefficient profile of modern annular blowout preventers during closure.

ACCOMPLISHMENTS

Tasks 1a and 1b have been essentially completed. A 9000 ft. well with 7.265 in. casing and valued in excess of $400,000.00 has been acquired on the LSU campus which is suitable for use in the well facility needed to model the deep water well control process. The Petroleum Engineering Department has been allocated a 1.4 acre tract of land containing the well by the University to support the development of the improved research facility. The location of the proposed research facility is shown in Figure 1. A more detailed site plan showing the dimensions of the allocated land is shown in Figure 2. Given in Figure 3 is a plot plan of the equipment layout. Figure 4 shows a flow schematic of the surface equipment and Figure 5 shows a schematic of the proposed well completion.

The experimental work for Task 4a is continuing. Minor flow loop modifications at the existing training well have now been completed and data is now being taken over a wider range of flow rates and choke pressures.

PROBLEMS

Problems have been encountered in the field fabriaction of a 2400 psi working test stand needed to complete task 4b. Personnel with Shaffer Division of N.L. Industries were contacted for assistance and Shaffer has volunteered to fabricate the test stand for us at their Beaumont Plant. In addition, Shaffer has agreed to instrument our annular blowout preventer so that the valve position can be readily recorded. Delivery of the fabricated equipment is expected by the end of the month.

Problems have also been encountered in obtaining the needed instrumentation for Task 4b. Halliburton was contacted for assistance and they have agreed to provide us some of their in-house research equipment at their cost.

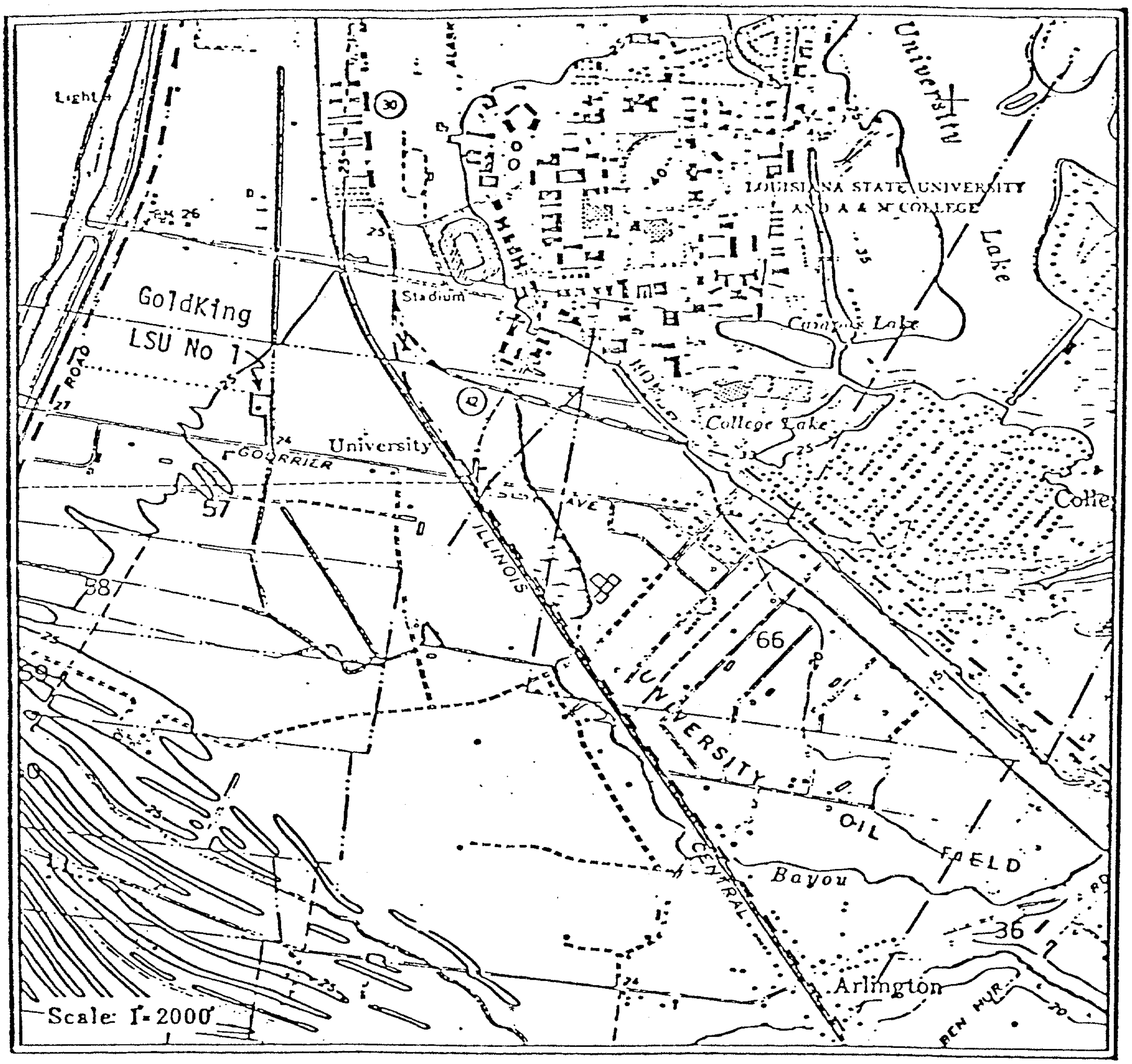
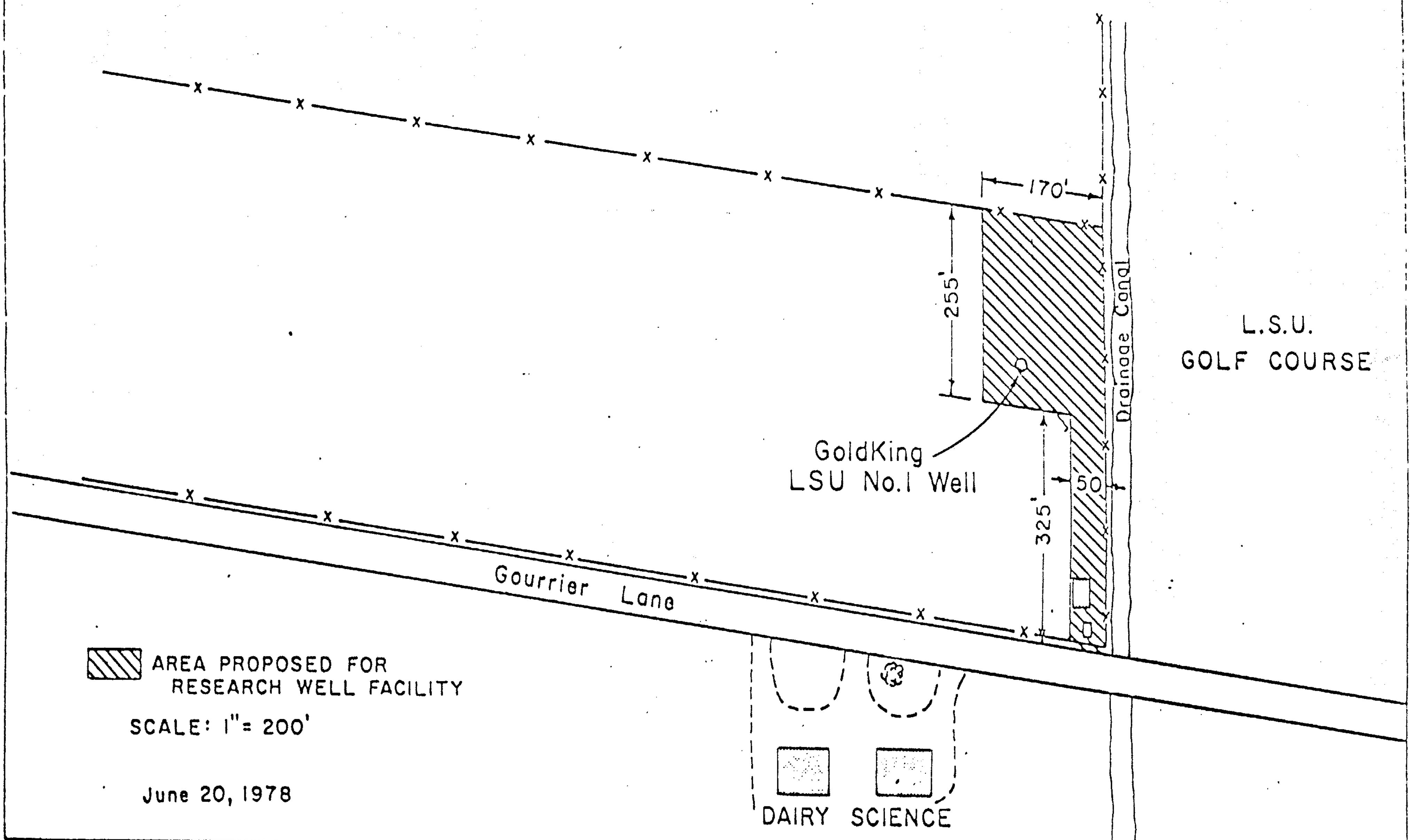


FIGURE 1 - LOCATION OF PROPOSED RESEARCH WELL FACILITY FOR DEPARTMENT OF PETROLEUM ENGINEERING (GOLDKING LSU NO. 1)

FIGURE 2 - SITE PLAN OF PROPOSED RESEARCH WELL FACILITY



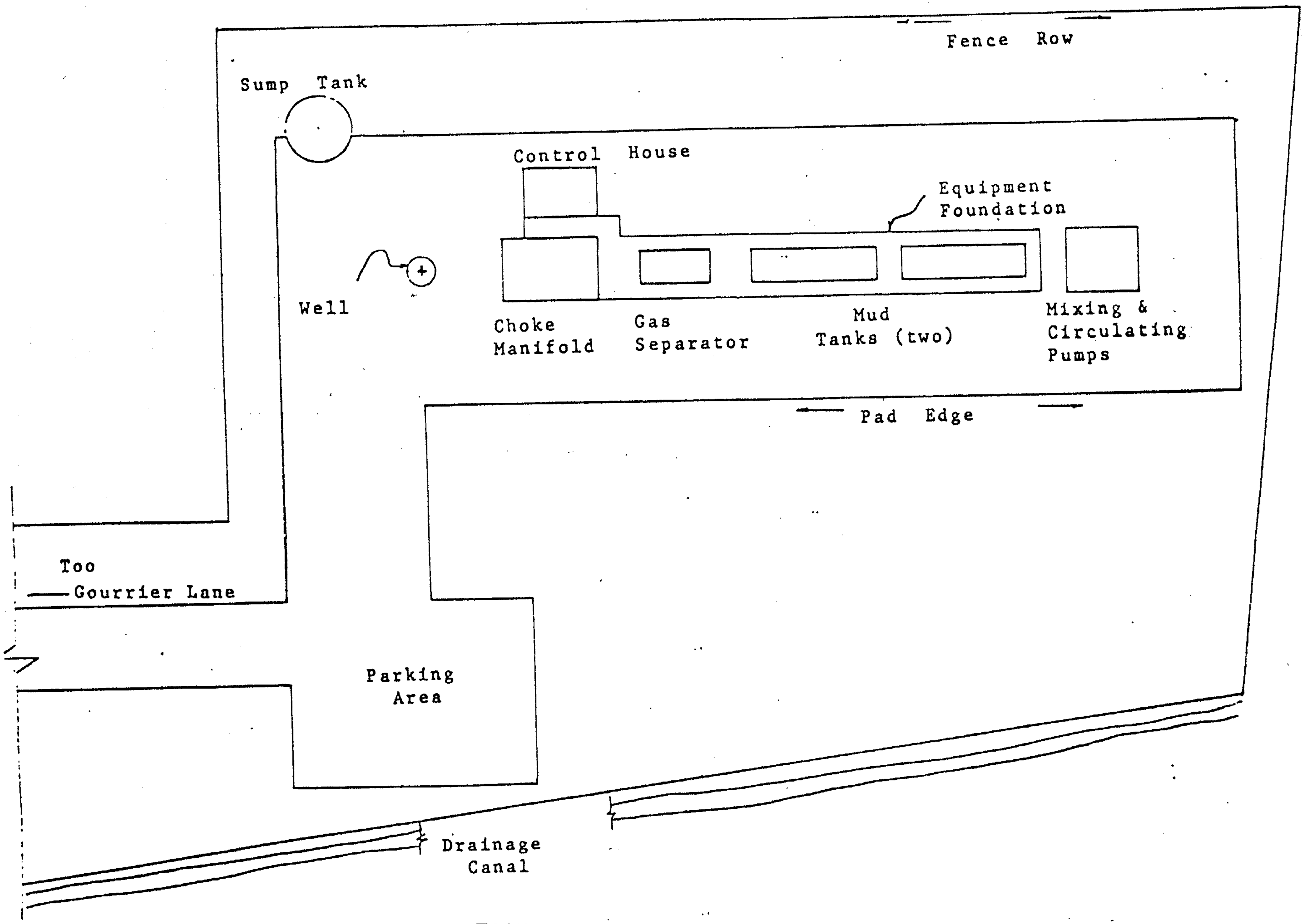


FIGURE 3 - PLOT PLAN OF PROPOSED RESEARCH WELL FACILITY

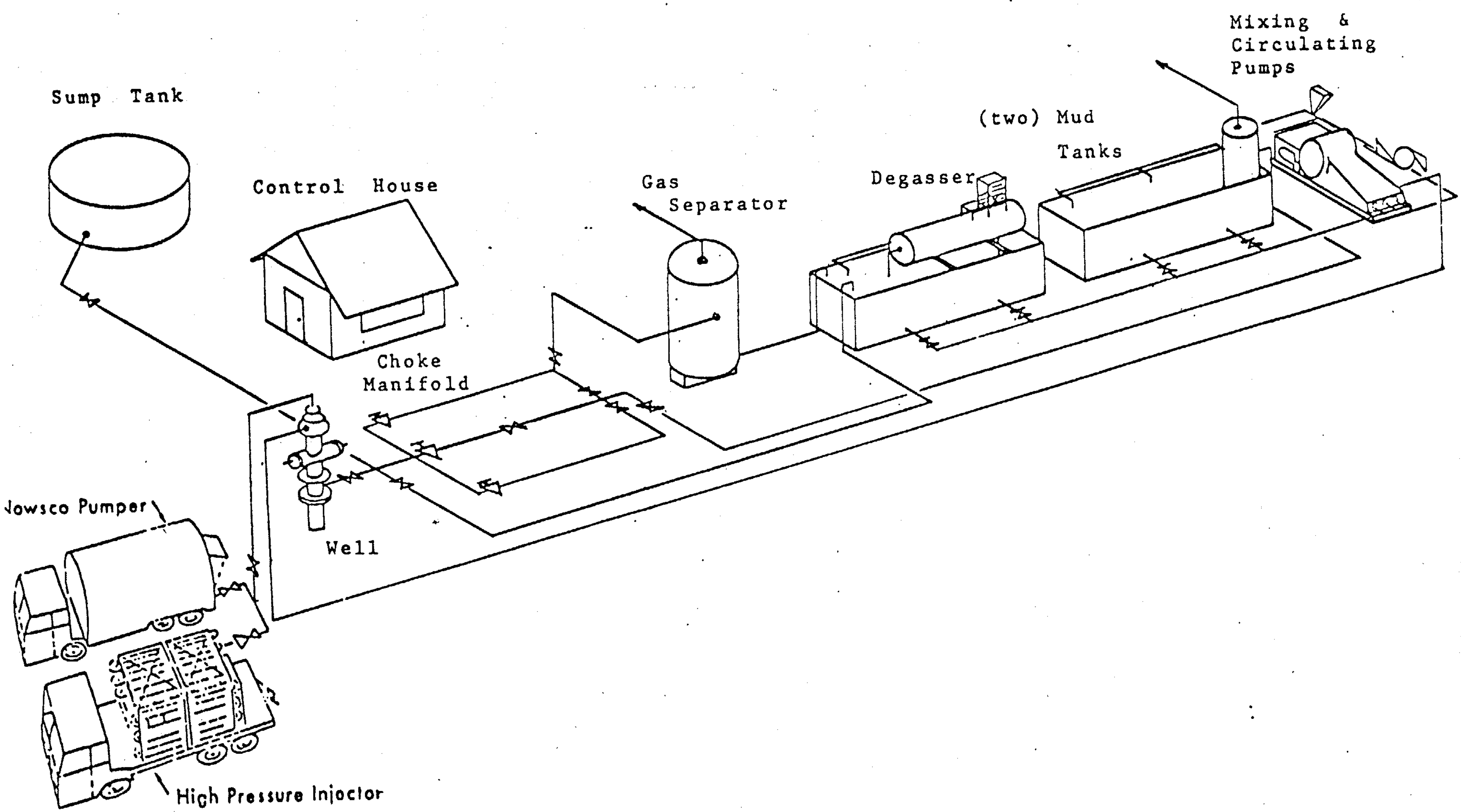
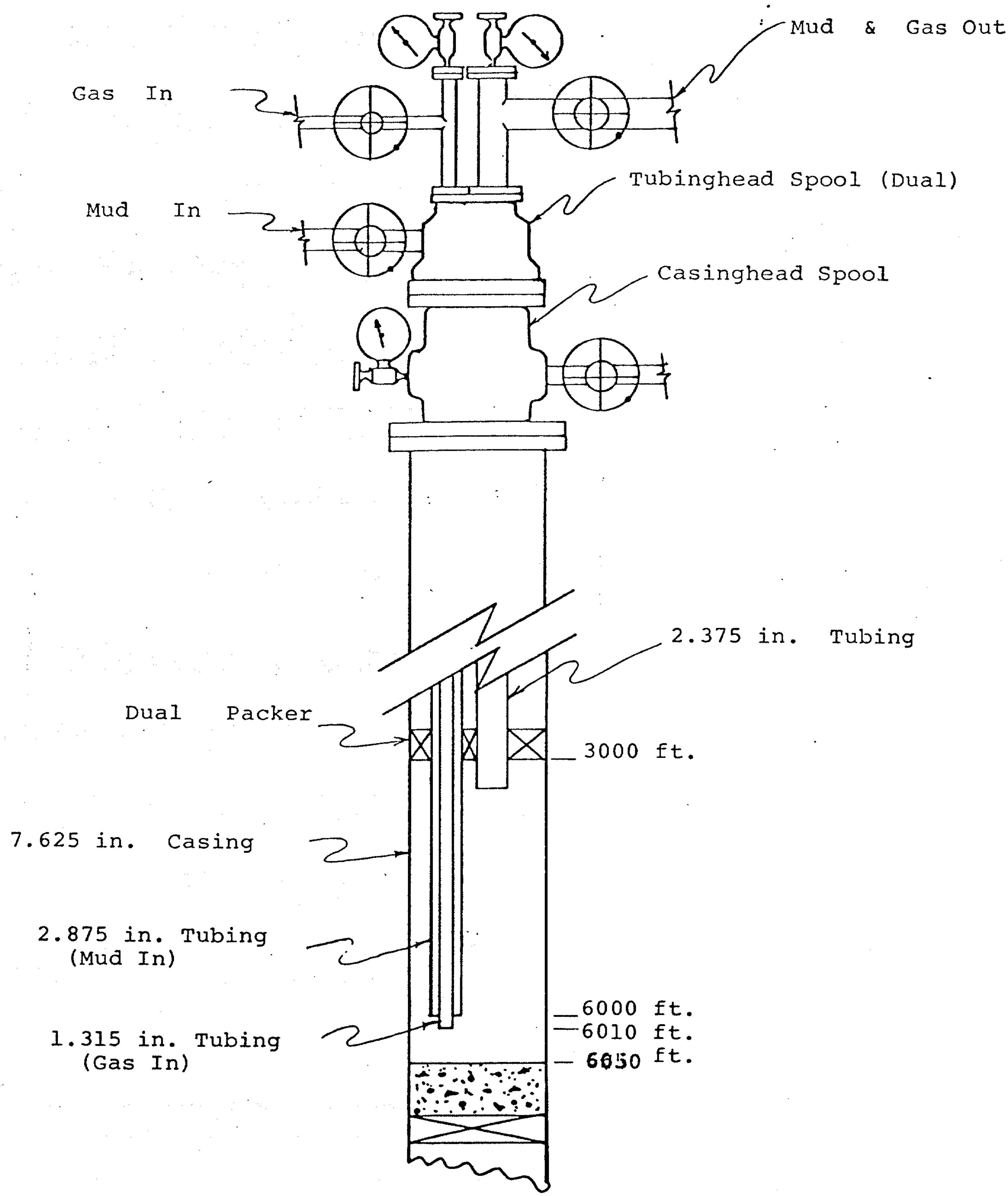


FIGURE 4 - SCHEMATIC OF PROPOSED
RESEARCH FACILITY

FIGURE 5 - SCHEMATIC OF PROPOSED RESEARCH WELL (INSTRUMENTATION NOT SHOWN)



CHANGES

No significant changes have been made in the project since our last progress report.

Adam T Bourgoyne, Jr

Adam T. Bourgoyne, Jr., Chairman
Petroleum Engineering Department